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William S. Regan

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AN INTRODUCTION TO THE SUBFAMILY PSAMMOCHARINAE.

By

William S. Regan.

Thesis Submitted for the Degree of Doctor of Philosophy.

Massachusetts Agricultural College.

Amherst, Mass.

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An Introduction to the Subfamily Psammocharinae,
With Particular Reference to the American Species
of the Genus Lophopompilus Rad.

Introduction.

The study of the subfamily Psammocharinae has formed a portion of the work done by the writer in the Entomological Laboratory of the Massachusetts Agricultural College for the degree of Doctor of Philosophy, under the supervision of Dr. Henry T. Fernald to whom the writer wishes to express his deep appreciation and indebtedness for the kind assistance and encouragement given him. To Dr. G. C. Crampton, also of this department, the writer is under many obligations and is very grateful for the aid given him in this work.

Preliminary to beginning the study of this group, all available material was obtained from various museums and private collections in this country, Dr. Fernald very kindly assuming the responsibility for such loans. In this way, not less than 5000 specimens have been at hand, consisting of material collected over a wide geographical range, from Alaska, various parts of Canada, some of these latter being from Vancouver Island and Newfoundland, from practically all over the United States, Mexico, the West Indies, Central and South America, and in addition many specimens from the Palearctic, Oriental and Australian faunal realms. These loans include material from the Leland Stanford University collection, the Colorado Agricultural College, Montana Agricultural College, material collected during the boll weevil investigation

work in Texas, from the Alabama Polytechnic Institute, New York State Museum, Brooklyn Museum, North Carolina State Department of Agriculture, the American Museum of Natural History, New York City, Children's Museum, Brooklyn, the Collection of the American Entomological Society, the United States National Museum, New Hampshire State College, Rhode Island College, Museum of Comparative Zoology, Cambridge, Bussey Institute of Harvard University, Boston Society of Natural History, the collection of the Massachusetts Agricultural College, and a number of private collections. In the case of many species, there have been numerous duplicates, and, through the kind permission of some of the owners, the writer has been able to make the necessary dissections for the study of genitalia, antennal sense organs, etc. To those who have so kindly made these loans, the writer is very grateful.

In addition to this material, the writer has personally examined carefully most of the type specimens of the American species of this group both in the United States and abroad, aggregating more than 200 species, including those of E. T. Cresson, Sr., Fox, Viereck, Robertson, Banks, Frederick Smith, Cameron and others. In many instances, it was possible to make homotypes by a comparison of specimens taken along for this purpose with the type.

The writer is indebted to many persons for various services rendered him in carrying out this work and wishes to express his appreciation for this assistance. To Mr. E. T. Cresson, Jr., Mr. Nathan Banks, Mr. Henry L. Viereck, Mr. S. A. Rohwer and Mr. Rowland E. Turner, the writer is especially grateful for their

many kind services. To Mr. Arthur H. Armstrong, of the class of 1907 of the Massachusetts Agricultural College, whose death occurred shortly after he had begun work upon this group, credit must be given for its initiation.

EXTERNAL ANATOMY

Integument

The chitin covering these insects is of uniform development and distribution and its surface for the most part is covered with fine appressed sericeous hairs, which often give a changeable silky or velvety luster. This covering is more or less evenly distributed over the surface, with occasional variation as, for instance, in the genus Lophonompilus Rad., to which more special attention will next be given. In this genus the covering is normally more dense upon the thorax than upon the rest of the body. Here in certain locations it assumes a very thick or tomentose character, especially upon the median segment, upon the anterior portion of the metanotum (the morphological metascutellum) upon the mesoscutellum and to a lesser degree upon the pronotum. In other positions the covering may be very sparse or entirely absent, so that the smooth chitin is exposed giving these areas a glistening appearance. Upon the head the sericeous covering is rather evenly though sparsely distributed being, however, slightly more dense upon the clypeus than elsewhere.

The abdomen usually has a more shiny appearance than the rest of the body due to the reflection from the smooth, somewhat exposed chitin, which, in this region, is rather sparsely furnished with sericeous hairs, these hairs attaining some degree of density only on the apical segments. Scattered over certain portions of the body and its appendages in the species of the genus under consideration, and more or less dense and localized, are rather long, slender hairs which stand up conspicuously above the appressed sericeous covering giving these insects a somewhat shaggy appearance, an important characteristic of the

species of the genus Lophopompilus. The species of certain other genera also have this hairy character quite conspicuously (e. g. Pycnopompilus Ashm., etc.) while in the species of many other genera it is present to a greater or less extent. These hairs are almost of uniform length and are distributed thickly over the head, thorax, the anterior portion of the first abdominal tergum (the morphological second abdominal segment) and very sparsely over the rest of the abdomen, the coxae and femora. In consequence of the habits of the females in searching for their prey in secluded places, both above and below ground and digging nests for their young in the soil, the vestiture upon certain portions of the body may become worn off, giving these areas a smooth, shining appearance. This condition is most liable to be found upon the clypeus, the top of the head, upon the mesonotum and dorsum of the abdomen, so that when reference is made to the vestiture upon any particular portion of the body some allowance should be made for the possibility of wear. Where the chitin is exposed it appears to be minutely punctate, these punctations evidently being the insertion points of the hairs. The vestiture of the males is normally coarser and more dense than that of the females. Bristles and bristle-like hairs are also characteristic structures which occur to a varying extent upon certain parts of the body and appendages in the different species. These vary considerably in their development, the more slender ones being difficult to differentiate from the body hairs, but all are quite distinct from the much stronger and coarser spines of the legs.

Color

In the case of the species of this subfamily color appears to be almost entirely dependent upon the nature of pigmentation of the cuticula, the vestiture usually being similarly colored. However, in the case of certain species, a violet, bluish or greenish iridescence often occurs which appears to be due, at least in part, to the presence of the appressed sericeous hairs rather than to the cuticula, as areas upon which this sericeous covering has been worn off do not have this iridescent character. In the experience of the writer, not only in the genus Lophopompilus, but in many other genera of the subfamily Psammodrominae, the several distinct color patterns are often in a general way broadly indicative of the genus into which a species will fall after consideration has been given to other characters. This, however, should not be taken to imply that all species having the same color pattern belong to the same genus, nor that all specimens belonging to the same genus and of exactly the same coloration are of the same species. The inference that such is the case has not infrequently been a source of error. In many instances color appears to have been given a greater value than it deserves in the systematic work upon this group, the result being that excellent morphological characters which would serve for separation of species have been overlooked. The following examples will perhaps bring out these points. The species Lophopompilus ephippiger Sm. and Psammodromus? tropicus Fabr. (Sphex tropica Fabr., Syst. Ent., 1775, p. 350.) are practically of the same size and color, both being black with the second abdominal segment orange-yellow, and of the same geographical distribution,

yet these two species fall in distinct genera. Again in the genus Lophopompilus the species atrox Dahlb., and ephippiger Sm., which are almost identical in their distribution, size and color, this being black with the second abdominal segment orange-yellow, appear not to have been identified as distinct species by systematists in this country up to the present time, in spite of the fact that there are excellent morphological characters by which these species can be separated. The same relation exists between Lophopompilus aethiops Cress., and Lophopompilus n. sp., described upon a later page, both species being blackish in this instance. Yet these two species have not previously been identified as distinct, although they are readily separable by the aid of morphological characters. In the genus Lophopompilus so far as the writer has been able to determine in the case of both native and exotic species, two color patterns are found according to the species. One is blackish and immaculate, as in the case of aethiops Cress., przewalskii Rad., n. sp. etc., the other is black with the second abdominal segment orange-yellow, as in the case of atrox Dahlb., ephippiger Sm., grandis Eversm., samariensis Pall. etc. The occurrence of the color band of orange-yellow upon other abdominal segments than the second, at least so far as the American species of this genus are concerned, is distinctly a color variation.

Head (Fig. _____)

The head is more or less lenticular, somewhat broader than thick. The vertical and transverse axes are of about equal length, though if the mouth parts in their usual more or less exerted position are taken into considera-

ation the vertical axis is slightly the longer. With the exception of the dividing line between the clypeus and frons, which is here termed the clypeo-frontal suture, the sclerites of the head are more or less completely fused, so that their limits are somewhat indefinite. This suture is a quite clearly defined transverse depression extending in a somewhat irregular zigzag line between the inner lower angles of the eyes. Towards the sides of this suture, and a short distance from each eye is located the attachment of the anterior arm of the tentorium.

Clypeus.- The shape of this sclerite varies considerably in the different genera and to some extent in the different species of the same genus, as well as in the two sexes. In the genus Lophopompilus it may be described as more or less convex, semi-circular in outline, its lower margin being rounded and having a median emargination or excavation (female only) and its upper margin being nearly straight and defined by the clypeo-frontal suture. The nature of this emargination of the clypeus in the females varies according to the species, but is usually either broad and shallow or narrow and deep. The margin itself is usually smooth and shining and destitute of vestiture and may be either thin and sharp or somewhat thickened with a more or less distinctly defined rim.

About mid-way between the lower and upper margins of the clypeus and located upon its convex surface is a transverse row of bristle-like hairs, which are readily distinguished from the surrounding vestiture. The number of these bristle-like hairs is constant to a certain extent for the species of a genus, but varies considerably in the different genera. In the genus Lophopompilus there are usually five or more, while in other genera they may be of varying numbers, entirely absent,

or at most weak and irregularly placed, as in Batozonus Ashm., and Poecilopomilus Ashm.

In the females the clypeus is frequently much worn, this condition probably being brought about during the process of nest digging. In the males the clypeus is never emarginate, being at most gently arcuate.

Frons.- This sclerite is more or less convex and quadrate in outline and is here taken to designate that region of the head included between the inner margins of the eyes laterally, the clypeo-frontal suture below and the fronto-vertical ridge above. The fronto-vertical ridge may be defined as a transverse, more or less distinctly marked elevation extending across the top of the head about on a line between the posterior margins of the tops of the eyes. The degree of convexity of the frons varies with the different genera and to some extent in the different species of the same genus. The ocelli occupy a median position near the upper margin of this sclerite and the more or less elliptical-shaped scrobes or insertions of the antennae a similar position near its lower margin, just above the clypeo-frontal suture. The scrobes lie quite closely together, the distance between them being about half that from either scrobe to the nearest eye margin. Between the scrobes the frons is drawn out into a bluntly rounded area, from the center of which a median, more or less distinct groove extends to the anterior ocellus.

Vertex.- As has already been indicated this sclerite is taken to extend anteriorly to the fronto-vertical ridge. Posteriorly it extends to the occipital ridge, a clearly defined elevated rim which extends around the hinder median portion of

the head and separates the vertex and genae from the saucer-shaped occiput. Laterally there is no dividing line between the vertex and genae, but this division is taken to lie in two parallel lines drawn posteriorly from the upper inner margins of the eyes to the occiput, making the vertex about two to three times as wide as long. The vertex may be either more or less convex posteriorly with a gradual slope to the occiput, or somewhat flattened with a rather abrupt slope.

Genae.- These occupy an antero-lateral position upon the head and extend from the dividing lines between these sclerites and the vertex at the top of the head, as already indicated, to the buccal cavity below. Antero-posteriorly they extend from the hinder margins of the eyes to the occipital ridge and are about one-third as broad as high. In some cases they are strongly convex posteriorly, while in others they are more or less flattened and slope abruptly to the occiput, this latter condition being more pronounced in the males than in the females.

Malar Space.- This term is employed to designate the narrow region on each side of the head lying between the base of the mandible and the lower margin of the eye. It is usually very narrow, being several times as long as broad, and varies but little in the different genera. It appears to consist of a very narrow extension from the lower corner of the frons which separates the eye from the clypeus, and a somewhat similar extension forward from the gena, these two processes uniting without any evident suture.

Organs of Vision

Eyes.- The compound eyes occupy an antero-lateral position and take up the greater part of the sides of the head,

and are approximately twice as long as broad although this ratio may vary considerably in different genera. They are convex-oval, slightly narrowed and rounded above, and more broadly rounded with a suggestion of angularity below where they meet the malar space. The posterior or outer margin is gently, convexly arcuate, while the inner margin has a slight emargination upon its upper half, giving the eyes a somewhat reniform appearance, especially noticeable in the males. The inner margins of the eyes either lie almost perpendicularly to the clypeo-frontal suture and parallel to each other, or beginning with the junction point of the malar space and the clypeo-frontal suture converge gradually above, the degree of convergence differing with the species. In the males the inner margins almost invariably occupy a more perpendicular position than in the females. They are usually grayish in color in dry specimens with a narrow rim of black, but may vary considerably.

Ocelli.- These are located at the top of the head between the eyes, just anterior to the fronto-vertical ridge, are three in number, more or less hemispherical in shape, and vary in size, degree of prominence or convexity and in color, which ranges from a transparent to a translucent amber. These organs are situated in the form of a triangle, there being one anterior, lower or front ocellus and two lateral, posterior or upper ocelli. The anterior ocellus is usually slightly larger than the others, which are of equal size. The distance from the anterior ocellus to either of the laterals is about half the distance of the laterals from each other. The distance between these often bears a constant relation to the distance between either lateral ocellus and the nearest eye margin in specimens

of the same species, and in distinct but related species there is often a constant ratio of these distances which is serviceable, this relation being due to the degree of convergence of the eyes in the species concerned rather than to any marked difference in the position of the ocelli. The distance between the two lateral, posterior or upper ocelli will be designated the postocellar line in this paper and the distance from either lateral, posterior or upper ocellus to the nearest eye margin the ocellocular line.

Mouth Parts

Only the labrum and mandibles appear to present characters which are readily available for classification, so that other parts will not be considered.

Labrum.- This structure in the case of most genera is attached to the inner surface of the clypeus and lies behind the latter in such a manner that as a rule only the apex is visible. The extent of excertion, however, is widely variable, even for the same species. In outline the labrum is more or less semicircular and is either convex upon its outer surface (Batozonus, Arachonophroctonus, etc.) or flattened (Lophopompilus, Pycnopompilus, etc.) the sides being well rounded, while the lower margin may be truncate, arcuate or rounded. In some genera the labrum is medially incised (Batozonus, Poecilopompilus, Arachrophroctonus, etc.) while in the genus Lophopompilus and in most other genera it is entire. The outer surface of the excerted portion of the labrum is covered with fine hairs, except for a narrow marginal area, and the lower edge is furnished with two rows of stiff bristles, one above the other. These bristles vary in size and length, the lower row being the shorter and stouter and of uniform length, while in the upper

row the bristles occupying a median position are short and those at each side long and slender. In certain genera (Allocyphonyx, etc.) the labrum is quite different in structure and in its position from that of the type already outlined, being exerted for the greater part of its length and lying below the clypeus. This type is destitute of marginal bristles and its degree of exertion moreover, is practically constant.

Mandibles.- (Plate fig.) These structures differ considerably in size and shape in the various genera and also to some extent in the different species of the same genus, being in general quadrangular at the base, and strongly narrowed and two-edged towards the apex. The anterior and posterior sides are the narrower and taper strongly from the base to about half way to the apex, where they assume a quite sharp condition. These sharp-edged portions will be referred to as the anterior and posterior margins respectively.

Located upon the anterior margin and at a varying distance from the apex may be one or two short, more or less bluntly pointed teeth. In the females of most species this margin is bidentate, that of the males unidentate. However, in certain genera and even in different species of the same genus, exceptions to this more usual structure occur. In the genus Arachnophroctonus the mandibles of both sexes are unidentate, while in Lophopompilus the females of certain species (atrox, aethiops, etc.) have bidentate mandibles and in n. sp. these structures are unidentate in this sex. In the genus Aphiloctenus both sexes, of some species at least, have bidentate mandibles.

The outer or lower and the inner or upper surfaces of the mandibles taper gradually to the apex, which may be bluntly rounded or sharply pointed in different instances. The

outer surface becomes convexly rounded-out apically, while the inner surface is more or less flattened or concave in this location. The basal portion of the outer surface is provided with fine, appressed hairs, which are lacking towards the apex, and is sparsely furnished with rather long, hair-like bristles.

Two quite distinct types of these organs occur, between which many gradations are to be found. To the first and by far the more common type belong those mandibles which are more or less broadly curved from base to apex, or sickle-shaped, and which occur in the genera, Batozonus, Poecilopompilus, Pycnopompilus, Lophopompilus and in other genera more or less typically. Mandibles of this type are usually well developed, their length being nearly or fully equal to the breadth of the clypeus, and their width more or less inversely proportional to their length.

To the second type belong those mandibles which are either straight or curved but little and more or less flattened. (Arachno phroctonus, etc.) Mandibles of this type may be narrow or broad, but more often the former, and are usually short, their length being equal to about half the breadth of the clypeus. The mandibles of the females are not infrequently considerably worn at the apex, so that their original structure may not be definitely evident. When this condition occurs due allowance should be made, so far as possible, if the characters of these structures are to be used successfully in classification. This worn condition of the mandibles in the females is undoubtedly brought about during the nest digging process in the soil, these organs evidently being used to a considerable extent in this work. The mandibles of the males are usually much smaller than

those of the females and comparatively poorly developed, approaching in their structure those of the females of the second type referred to.

Antennae.

These organs are inserted upon the lower portion of the frons and, with few exceptions, are of the filiform type. (Plate fig.). Each consists of a scape, a pedicel and a flagellum of ten segments in the female, and eleven in the male. The bulb or basal portion of the scape which articulates with the head is small, more or less spherical in shape and projects but little beyond the surface of the frons. The scape proper is usually well developed, subcylindrical and has a somewhat greater diameter than that of the segments of the flagellum. The length of the scape may differ considerably in the two sexes and to a greater or less extent in species of distinct genera. There is practically always a sexual difference, although this difference is less marked in the two sexes of some genera than in others. In the species of the same genus or allied genera, the relative lengths of the antennal segments is very similar, while in distinct genera the difference in these segments may be quite great. In the females of most species the length of the scape is less than that of the first segment of the flagellum. In the genus Sophropompilus the antennal segments of both sexes are much shortened and the length of the scape is about equal to that of the first segment of the flagellum. This is also true of most males throughout the group. In the genera Batozonus and Peocilopompilus, however, the scape is somewhat reduced in length and shorter than the first segment of the flagellum.

The pedicel is a very short segment, subcylindrical,

usually about as broad as long and varies but little in the different species. The segments of the flagellum are cylindrical, with certain exceptions, and taper gradually to the apex, the diameter of the apical segments being but little less than those at the base. The exceptions alluded to which vary from the usual cylindrical type occur in the genera Batozonus and Poecilopompilus, in the species of which these segments are rather strongly convex ventrally, a condition which will be termed "crenate" in this paper.

The length of the first segment of the flagellum as compared with the second and following ones differs for certain genera and in the two sexes. In the females of most species the first segment is the longest segment of the antenna, the second and following segments being subequal and each usually a fraction shorter than the one preceeding, with the exception of the terminal segment, which is almost invariably a little longer than the penultimate. In the males throughout the group and in both sexes of the genus Sophropompilus the segments of the flagellum are subequal and with only a gradual diminution in length from the first to the terminal segment.

Antennal sense organs and structures.- Within the subfamily Psammocharinae the antennae present a number of important and diversified structures, some of which are more or less distinctly apparent under the binocular with a magnification of sixteen diameters. The antennae of the females present several different types and those of the males also several types, most of which are of quite distinct structure from those of the females. Those organs which are readily visible under the binocular with a magnification of from sixteen to sixty-five dia-

meters are here referred to as submicroscopic structures, while those requiring greater magnification are in general termed microscopic structures. As a matter of convenience and clearness the antennae will be considered as extending out sideways and at right angles to the side of the head, the terms anterior, posterior, dorsal and ventral being used to indicate these respective regions, the antennae being so placed, regardless of their natural position.

Females.- In this sex two submicroscopic types of sense organs occur, somewhat similar in structure, but differing in their location and size, and only one or both of these types may occur upon the same antenna. The first type, which will here be referred to as the longitudinal sense area or organ, occurs upon the antennae of all species throughout the subfamily, and occupies approximately the anterior transverse third of each segment of the flagellum, extending from the base to apex with the exception of the first segment, where it is usually lacking towards the base. This organ covers the greatest area upon the middle segments and decreases considerably in size towards the base of the flagellum and to a lesser extent towards the apex. The extent of this organ also differs in certain genera, for example being large in Lophopompilus and comparatively small in Batozonus. The scape and pedicel are destitute of sense organs.

The longitudinal sense organ is distinguishable from the rest of the antennal surface in one or more of several ways. The color is usually lighter than elsewhere, possibly due to thinner chitin here than upon the non-sensitive portion, or this sensitive region may be more or less elevated, flattened or even depressed, and has the appearance of being covered with

minute openings or pores. The first two characters are not always serviceable, that of color being especially useful in the case of blackish antennae, whereas in some of the light colored species, the antennae of which are yellowish or ferrugineous, no color difference is usually evident. In most species the segments of the flagellum are uniformly cylindrical and the sensitive longitudinal area is faintly elevated above the surrounding surface, as in the genus Lophopompilus, etc., while in the genus Sophrpompilus, this region may be flattened or even depressed. The appearance of the sensitive area as if covered with minute circular openings or pores seems to be invariable, although a rather high magnification with the binocular may be required in certain cases to detect these.

The second submicroscopic type of sense organ upon the female antenna consists of two similar, more or less circular or oval areas, which occupy a central or subcentral position upon the dorsal and ventral surface, respectively, of the segments of the flagellum, and lie directly opposite to each other. The longitudinal sense organ lies between and contiguous to these upon the anterior surface. These structures will be termed the central sense organs. They occur only in certain genera and when present can readily be distinguished by their smooth, shining appearance and by their slightly depressed surface. These areas do not occur, so far as the writer has been able to determine in Ashmead's genera Arachnophroctonus, Batozonus, Spilopompilus, Poecilopompilus, Pycnopompilus, Sophrpompilus, Sericopompilus and in other genera, the longitudinal sense organ alone being present, while in Lophopompilus, Pompilinus, Aphiloctenus and in certain other genera both types

are found. The size of the central sense organs also varies to quite an extent, those upon the apical segments being considerably larger than the ones towards the base, there being a gradual diminution in the size, and the organs upon the ventral surface being distinctly larger than the dorsal ones of the same segment. This condition would seem to indicate that the apical ventral segments are the more sensitive, so far as the function of the central sense organ is concerned. There appears to be little difference in the size of these organs in related species, but there is sometimes an appreciable difference for those more remotely related. In the genus Lophopompilus both types are present and are well developed.

In order to make a comparative study of the morphology of the sense organs and other antennal structures in the species of the various genera, antennae were removed from a number of specimens, boiled in 10 percent caustic potash and mounted for microscopic examination in the usual manner. Under the microscope the longitudinal sense organ appears to be dotted with circular, elevated spots, each with a central depression from which a short bluntly conical process projects slightly above the general surface. From the base of each depression a vase-shaped cavity in the chitin extends, enlarging within to the inner surface of the antenna, the diameter of the internal openings of these organs being somewhat larger than that of the surface pore.

Lubbock ("On the Senses, Instincts and Intelligence of Animals," p. 58) gives the number of "pits" for Pompilus as 3,000, but since the longitudinal sense organ occurs in the females throughout the several subfamilies of the family Psammocharidae, with the exception of the subfamily Ceropalinae,

and since the genus Pompilus in the sense in which Lubbock used it represented this entire family as it now stands, this number can at best be taken as only broadly approximate, for it is evident that as the size of these organs varies considerably in the different divisions, the number of pores must be correspondingly variable.

Numerous authors have written upon the morphology and probable function of the antennal sense organs, and there appears to be considerable difference of opinion as to just which particular sense should be attributed to each of the various structures. Most writers are in accord that the antennae are highly sensitive to touch and are at least in part the seat of the sense of smell. Evidence to the effect that certain antennal organs may have an auditory function, while not conclusive, is at least strongly suggestive. The writer has no proof to substantiate his conclusions in regard to the function of certain antennal organs found in this group, and, not having made histological studies of them, the purpose of this paper being morphological rather than histological, these data are offered with reserve. It has seemed only logical to conclude, however, that two well developed and somewhat distinct types of structures occurring upon the same antenna have not the same function. The conclusion is therefore ventured from the nature and location of these organs and by a process of elimination, that the antennae of certain species of this group are the seat of at least three senses, in all probability those of smell, touch and hearing.

Schenk ("Die antennalen Hautsinnesorgane einiger Lep. und Hym.," Zool. Jahrb. Abth. fur Anat. 17, p. 573) describes various types of sense organs occurring upon the an-

tennae of certain Hymenoptera, some of which appear to be quite similar in structure to those found in the subfamily Pasmmocharinae. The pores and short, blunt processes upon the longitudinal sense organs are evidently a form of Schenk's sensillum basiconicum, to which he attributes an olfactory function.

The surface of the central sense organs is also dotted with minute pores, which are more closely set and smaller in size than those upon the longitudinal sense area, but are in general of much the same structure. Each pore of the central sense areas, however, appears to give rise to a slender bristle, which projects above the general surface of these organs. This type seems not to agree in detail with any of those discussed by Schenk, but the writer ventures the opinion that their function may be auditory, the depressed position of these organs being more in accord with such a function than either that of smell or touch. The details of the structure of the central sense organs, as in the case of the longitudinal areas, appear to be similar in the different species in which these organs occur.

Two types of integumental structures the characters of which can only be determined under the microscope also occur upon the antennae. The first type consists of minute hairs or spines of various sizes, those upon the non-sensitive portions being somewhat similar to the fine hairs found upon the body, while the pores of the sensitive areas are interspersed with still finer, scarcely perceptible spines. Somewhat coarser spines or hairs frequently occur at the apices of the segments.

The second type consists of translucent, polygonal spines, which originate in pores about mid-way in size between

those of the longitudinal and central sense areas, are depressed, lying parallel to the surface of the antenna, and are invariably directed towards the apex. In the females these spines do not occur upon the sense areas, except for an occasional isolated case and upon the scape and pedicel, nor upon the greater part of the first few segments of the flagellum, and are usually sparsely distributed or absent upon a narrow strip extending along the posterior side of the flagellum. Considering the distribution of the polygonal spines it seems probable that these are a form of sense organ, which may possibly have a tactile function.

Males.- As previously stated several types of antennal sense organs are present in this sex, which differ materially in their structure and location from those of the female antenna, two types being apparent under the binocular, the others microscopic. Of the former structures only one type occurs upon the same antenna. The more common type, and that which with few exceptions occurs in the sex throughout the subfamily, is situated upon the ventral surface of the segments of the flagellum and covers about the under half. With the exception of the base of the first segment and the extremity of the apical segment, this sensitive area covers the length of the flagellum.

Under the microscope this area appears to be more thinly chitinized than the rest of the antenna and is set here and there with erect, stout, opaque spines, which are largest at their middle and taper slightly towards the base and to a point at the apex, this portion being frequently considerably bent. These spines have their origin in bowl-shaped depressions and appear to be normally gently inclined in the direction of the

apex of the antenna, and are more numerous upon the middle and basal segments than upon the more distal ones. Structurally these spines are close to Schenk's sensillum basiconicum, and probably have an olfactory function being, however, quite different from the microscopic cone-shaped processes, which occur upon the female antenna.

These longitudinal sense areas of the male antenna vary to some extent in size and in the number of sense spines covering their surface, for certain genera, being, however, plainly visible under the low power of the binocular because of their color, which is lighter than that of the surrounding surface. In the species Psammochares?philadelphicus (Lep.) these sense areas are comparatively small, while in Lophopompilus they are well developed. In Arachnophroctonus the number of sense spines on the longitudinal areas is small compared with that of Lophopompilus.

The second type of sense organ found upon the male antenna apparent under the binocular which occurs only in Ashmead's genera Batozonus and Poecilopompilus, occupies a position at the base of each segment of the flagellum upon the ventral side, being well developed upon all segments except the first two. These organs are more or less circular in outline, depressed, usually have a smooth, shining appearance and each covers about one-fourth of the ventral surface of the segment upon which it is located. In species having dark colored antennae, as, for instance, Batozonus algidus (Sm.) etc., these depressed areas are conspicuous and readily seen under the binocular, but in species having light colored

antennae, such as Poecilopompilus interruptus (Say) etc., these areas are not as evident.

Unlike the spines upon the longitudinal sense areas of the male antennae, which are faintly visible under the binocular, the structures upon the depressed areas are entirely microscopic and are very difficult to observe. The principal sensitive organs upon these depressed areas appear to be erect, translucent, conical spines which are bluntly rounded at their tips and are about half-way in size between the minute spine-like hairs upon the general antennal surface and the polygonal spines previously referred to, both of which in this sex occur on the entire surface of the antenna. These conical spines also appear to be a form of Schenk's sensillum basiconicum, but differ in appearance from any of the other forms of this type which occur in either sex. Antennae having the depressed sense organ have in addition located at the apices of some of the segments a few large, erect spines, similar to those which occur upon the longitudinal sense areas of the males, and possibly serve a sensitive function.

Under the microscope a probable third type is seen, which occurs upon the antennae of both sexes. This consists of somewhat barrel-shaped organs located here and there over the segments of the flagellum, the outer surface of each being continuous with the general surface of the antennal integument. These organs are few in number, there being usually less than half a dozen to each segment, and appear to have immersed in them a sharp spine, which lies entirely beneath the general surface. In structure these organs closely approach Schenk's sensillum coeloconicum.

It is evident from the foregoing that in the subfamily Psammocharinae there is quite a remarkable difference in the structure and development of antennal sense organs, and in the number of these structures which are found upon the same antenna. The presence of two well developed apparent types of these organs in the females of the genus Lophopompilus, etc. as compared with the single apparent type of but medium development of this sex in Batozonus, etc., and the corresponding better development of these organs in the males of Lophopompilus over those of Batozonus, amply bears out this point and indicates one line, at least, in which the phylogenetic position of the former is probably in advance over that of Batozonus and allied genera. In general the development of the antennal sense organs of the females appears to be better than that of the males.

Thorax

The thorax is well developed and has a somewhat gibbous character, its length being only about twice as great as either its breadth or depth. The length of the thorax as compared with that of the abdomen varies greatly, in some cases being shorter and in other cases being longer than the latter, even in different specimens of the same species, this variation being due to the variable extent to which the abdominal segments may be telescoped. The numerous sclerites are usually well demarked, although the extent to which fusion has taken place appears to be greater in certain genera than in others, as for instance in the genus Sericopompilus in which the sutures between some of the sclerites are less distinct than in most other genera.

Prothorax.- The pronotum may be gently or convexly rounded above, falling off steeply towards the front and abruptly at the sides, the latter being more or less flattened. A distinct groove, transverse medially but extending downward and backward at the sides separates the short neck from the much larger posterior portion or collar. At the sides the neck is more or less convexly protuberant to form regions which will be termed the shoulders. Posteriorly the sides of the pronotum project back to the tegulae, these lateral extensions being broadly rounded and constituting the pronotal lobes. The lower portion of the sides of the pronotum are flap-like, thin, more or less broadly rounded at their extremities and extend to, or overlap the bases of the anterior coxae. The outline of the posterior, dorsal margin of the prothorax varies greatly in the different genera, in some cases being a broad obtuse, re-entrant angle (e. g. Pycnopompilus, etc.) and in others gently, very broadly emarginate (e. g. Lophopompilus, etc.) certain other genera presenting various gradations in the outline of this structure between these two types. A small portion of the propleuron is visible, which projects forward from underneath the sides of the pronotum.

Mesothorax.- Lying behind the pronotum and overlapped by this sclerite is the united prescutum and scutum of the mesothorax, usually termed the mesonotum. This sclerite is flattened or gently convex, its shape anteriorly depending upon the contour of the posterior margin of the pronotum. Its sides extend backward from the pronotal lobes, converging strongly to the posterior margin, which is truncate and very closely united with the scutellum, so much so that the dividing suture is often indistinct. The parapsides are triangular in

outline and are separated from the mesal portion of the mesonotum by the more or less apparent parapsidal furrows. Anteriorly a short, narrow, mesal region is demarked from the rest of the mesonotum by two parallel furrows, which extend backward from the posterior margin of the pronotum. Underlying the sides of the mesonotum and posterior but contiguous to the pronotal lobes are the tegulae. These are semicircular in outline, slightly convex above and, with the exception of the margin, are covered with sericeous hairs similar to those upon the body.

The mesoscutellum is somewhat shorter and narrower than the mesonotum and is semicircular or broadly horseshoe-like in outline, being truncate anteriorly and rounded behind. Medially this sclerite is continuous with the mesonotum, being flattened or gently elevated above the latter, but slopes away steeply at the sides, each side anteriorly being about equal in depth to the width of the median portion. Posteriorly the sides and median portion narrow perceptibly, the sides at the same time curving upward slightly, thus making the depth of the scutellum correspondingly less at this point.

The mesopleuron is a large, somewhat oblong-shaped sclerite which occupies the greater part of the mid-region of each side of the thorax and extends diagonally backward and downward from the pronotum and base of the wings to the mesocoxa. The lower posterior region of this sclerite is more or less flattened or concave, but it becomes evenly rounded towards the ventral side. The episternum occupies a latero-ventral position and constitutes the greater part of the mesopleuron, and is divided into two portions of nearly equal size, an upper

region (anepisternum) and a lower region (katepisternum) by a more or less distinct and complete transverse incised line, here termed the anepisternal suture. This suture usually terminates in a depression, just anterior and ventral to the meso-metapleural suture. This depression varies considerably in size, sometimes being small, shallow and more or less indistinct, as in the genera Batozonus, Poecilopompilus, etc. or it may broaden out into a conspicuous, sunken region, as in the genus Arachnophroctonus. The episternum is almost completely fused with the sternum, there being, however, the remains of a suture between these two sclerites, just anterior to the middle coxae upon the ventral surface. The epimeral region is a long, narrow, somewhat indefinite area, lying just above and behind the episternum. This region is depressed in its upper part, which lies just below the base of the wings, and is usually well demarked from the upper region of the episternum. Beyond the anepisternal suture, however, the epimeral region in some cases becomes evenly united with the lower region of the episternum and is consequently more or less obliterated. In Ashmead's genera Sericopompilus, Batozonus, Poecilopompilus, etc. the episternum and the epimeron are quite clearly demarked along the greater part of their length, whereas in the genus Lophopompilus and in certain other genera these sclerites are more or less closely fused beyond the anepisternal suture.

The surface of the mesopleuron in the region of the epimeron may be smooth, or transversely rugose in a somewhat conspicuous and characteristic manner. A noticeable difference in this respect, for instance, occurs in the species Arachnophroctonus ferrugineus (Say) and A. ruficolor Vier., the sur-

face of the epimeral region being rather smooth in the case of the former species and distinctly rugose in the latter. In the genus Lophopompilus a postero-dorsal area is characteristically and strongly rugose.

Lying anterior to the anepisternum is the crescent-shaped prepectus (hypopteron of Audouin, 1820.) This sclerite shows some variations in certain genera, but is quite frequently completely hidden by the side of the pronotum so that its structure is not easily determined.

Upon the ventral side of the thorax there appear to be few structures of importance, this region, for the most part, being occupied by the attachments of the coxae. The posterior portion of the mesosternum on each side of the midventral suture is usually produced backward between the middle coxae, forming the furcasternal region. These projections vary considerably in shape but are usually rounded, oblong or tooth-like, often being distinct for different species of the same genus. In Arachnophroctonus ferrugineus (Say) and A. ruficolor Vier., for example, the furcasternal region on each side of the midventral suture is oblong in the former, while in the latter species it is drawn out into a blunt tooth. However, due to the doubled-up position often assumed by these insects after death, or to the position of the anterior coxae which often lie back upon the sternum, the furcasternal region is frequently not available for examination.

Metathorax.- The anterior portion of the true metanotum, usually termed the postscutellum, is a rather narrow sclerite lying behind the mesoscutellum and extending forward at the sides of this plate, its lateral ends lying above the

hind wings. The median portion is swollen, the lateral parts flatter. Its lateral margin is broadly emarginate above the hind wing base, then extends sinuately backward and inward toward the mid-dorsal line of the body, in which region it forms a sort of a lobe projecting backward, partly concealing the median portion of the metapostscutellum, and, when viewed from directly above, sometimes a small portion of the median segment as well. A transverse ridge crosses the side of this plate just behind the hind wing, and another less pronounced is present about half way from this to the mid-dorsal line.

Dorsally the posterior portion of the true metanotum, the metapostscutellum, is represented by a narrow, transverse, depressed, groove-like region, lying between the postscutellum and the median segment. This narrowed region is usually transversely rugose and is destitute of the sericeous hairs which cover the rest of the thoracic sclerites. The surface of this plate becomes gently rounded out and broadened laterally, where it unites with the upper portion of the metapleuron, forming a somewhat triangular region, which is demarked below by the meso-metapleural suture. The lower portion of the metapleuron is roughly triangular in outline, being contiguous to the upper portion of this sclerite, and lies wedge-like between the propodeum and the posterior extremity of the mesopleuron, its surface being either gently convex or more or less flattened. Its lower posterior end articulates with the metacoxa.

Median segment.- The median segment or propodeum, commonly termed the metathorax in systematic writings, is the true first abdominal segment, but will here be considered along with the thoracic sclerites. This structure lies slightly

below and posterior to the true metanotum and occupies approximately the posterior third of the thoracic region. Its shape is extremely varied and often differs to a marked extent even for different species of the same genus. In a general way it may be said to be dome-shaped, or somewhat flattened above, and either slopes gradually or abruptly at the sides and behind, the posterior surface in different instances being rounded, flattened, grooved or broadly hollowed-out, and sometimes produced at the sides into blunt areas or pointed teeth, as in the genus Aporus.

The lower, posterior region of the propodeum projects backward as a narrow, ledge-like region, which may be thin or thickened dorso-ventrally and is either rounded or angularly pointed at the sides, according to the genus under consideration. In the genera Batozonus and Poecilopompilus the lower posterior projection of the propodeum is considerably thickened dorso-ventrally and the lateral projections of this region are angularly pointed, whereas in the genus Arachnophroctonus the lower posterior projection is quite thin dorso-ventrally and the sides are well rounded upon their outer margins.

The propodeal spiracles, two in number, are quite large and occupy an antero-lateral position upon the dorsal portion of the propodeum, a short distance behind the suture, separating this sclerite from the metapostscutellum. These organs are linear or slightly crescent-shaped and lie in a position about mid-way between the longitudinal and transverse axes. They vary little in shape and position in the various genera. The surface of the propodeum ~~just~~ anterior

to the spiracles is sometimes convexly elevated as in the case of species of the genus Arachnophroctonus, etc., though in most genera this region is more or less flattened.

Thoracic Appendages

Legs.- These are long and slender and admirably fit these insects for their cursorial habit when seeking their prey. The fore legs are the shortest, but these are nearly as long as the body, the middle and hind legs being slightly longer in order than the preceeding pair. The same sericeous covering which adorns the body is also present upon the legs and is rather evenly distributed, except for portions where it has become worn off. For convenience of orientation the legs will be considered as being directed at right angles to the body and the terms anterior, posterior, dorsal and ventral will be used to indicate these respective regions upon these appendages or their segments when so placed, regardless of their natural position.

Coxae.- The coxae occupy the greater part of the sternal region of the thorax, are lightly articulated with the sternum and are large and prominent, being by far the most heavily developed of the leg segments. Their shape is roughly pyriform, being large at the base and tapering more or less strongly towards the apex. The anterior coxae are fully as long, but not as thick as the middle and hind coxae, which are more nearly equal in size. The surface of the anterior coxae is gently convex antero-posteriorly, and more or less flattened dorso-ventrally. The surface of the middle coxae is gently convex antero-posteriorly, strongly so ventrally and concave dorsally, this cavity being provided for the reception of the trochanter and femur when the leg is flexed. The posterior coxae are some-

what flattened antero-posteriorly, strongly convex ventrally and concave dorsally, as in the case of the middle coxae.

Apically each of the coxae is deeply excised for the reception and articulation of the trochanters, these excisions being two in number and somewhat horseshoe-shaped. Upon the middle and posterior coxae these excisions occupy a dorsal and ventral position, respectively, the excision upon the ventral side being the shallower, whereas upon the anterior coxae these excisions are located upon the dorsal and posterior sides and are nearly of equal depth. This condition wherein the location of the apical excisions of the fore coxae differs from that of the middle and hind coxae would seem to indicate a region of movement for the fore legs different from that of the middle and hind legs, irrespective of the movement of the coxae themselves.

The anterior coxae are usually sparsely furnished with bristle-like hairs, while the middle and hind coxae are generally without these.

Trochanters.- These are short, stout segments, which may perhaps best be described as ham-shaped, being narrow at the base and broad distally. The articulation of the trochanters with the coxae is quite loose, which must permit considerable freedom of movement at this point, but the junction between the trochanters and femora is very close, each of the trochanters forming a sort of a tight cap over the base of the femur. The trochanters show little structural variation in the various genera.

Femora.- These segments may be described as sub-cylindrical, expanded slightly medially, and tapering more or

less strongly towards the apex. The middle, and especially the hind femora, are often perceptibly flattened posteriorly and shallowly grooved on the ventral side for a short distance back from the apex. The apex itself upon the ventral side is excised, as in the case of the coxae, for the articulation of the tibia, there being, however, but a single excision upon each femur.

The femora are at most weakly armed, there being in the case of most genera only a few short spines arising from pits upon the dorsal side near the apex. In Batozonus and Poecilopompilus these spines are more generally distributed over the surface, whereas in Arachnophroctonus the femora are practically destitute of spines.

The length of the fore and middle femora is usually slightly greater than that of the tibiae of the corresponding legs. The hind femora and tibiae are about equal in length.

Tibiae.- These leg segments may be described as subcylindrical, being narrow at the base and of slightly increasing diameter to the apex, where the diameter is about twice that at the base. The tibiae are sparsely armed with erect, strong spines, which are arranged with some degree of regularity in longitudinal rows, and also form an irregular fringe upon the apex. That portion of the surface of the tibia which normally comes in contact with the body is practically destitute of spines. In the case of the fore tibia this is the anterior surface, while upon the middle and hind tibiae the posterior surface is practically unarmed.

Upon the anterior surface of the fore tibia, and close to the apex, in the case of most genera, are located

two separate velvety areas composed of short, golden hairs. In the genera Batozonus and Poecilopompilus, but a single one of these areas occurs upon each of the fore tibiae, the extent of this single area, however, being about the same as the two separate areas in other genera. Upon the middle tibiae there is no trace of these areas, but upon the hinder pair a somewhat similar structure occupies a narrow, longitudinal area upon the posterior surface, extending from base to apex and broadening out just before the apex is reached. These velvety structures will here be termed the tibial scopae.

At the apex of the fore tibia is a single spur, having a serrated edge upon its dorsal side. This spur fits into a groove upon the ventral side of the metatarsus and probably serves as a cleaning apparatus. The length of this spur, which will be termed the tibial comb, varies considerably as compared with the length of the metatarsus of the fore leg, being nearly equal in length to the metatarsus in Batozonus and Poecilopompilus and considerably shorter in Lophopompilus and most other genera.

The middle and hind tibiae have two apical spurs upon the ventral side, the anterior one in each case being the shorter. The length of these spurs as compared with that of the metatarsus varies considerably in the different genera. Ventrally they are convexly rounded, but more or less flattened laterally and dorsally, each edge of the flat dorsalsurface being finely serrate. In the females of Batozonus, Poecilopompilus, Arachnophroctonus, etc., these serrations of the tibial spurs extend from the base to apex, whereas in the females of Lophopompilus and in certain other

genera they extend from the base to but little beyond the middle. In all males these serrations extend the full length of the tibial spurs, or fall but little short of this.

The long spur of the hind tibia has some short, stiff hairs upon the basal portion of its posterior, serrated margin, which, in combination with some similar hairs upon the basal portion of the ventral side of the hind metatarsus, probably constitute another type of cleaning apparatus.

Tarsi.- The segments of the tarsi are five in number and are usually more or less cylindrical in shape, or slightly enlarged distally, but in rare instances are flattened upon the ventral side. The first segment or metatarsus is the longest, the following ones being shorter in order, except the last, which is somewhat longer than the preceeding segment.

The tarsi are usually well armed with stout spines of various sizes, these being arranged somewhat regularly in longitudinal rows. In addition to these rows of spines there is an irregular apical fringe of spines upon each tarsal segment. The armature of the tarsi most commonly met with consists of a median and two lateral, longitudinal rows of closely-set, minute spines upon the ventral side, with an intermingling of additional spines or rows, as will shortly be indicated, the dorsal side of all the tarsal segments being practically unarmed.

Upon the fore metatarsus the posterior of these two lateral rows of spines upon the ventral side is usually inter-

spersed with a few spines of larger size, while upon the posterior side of the fore tarsi there is usually a longitudinal row of rather heavy, sparsely-set spines, these generally being distinct from the others by their larger size. This row occurs only upon the fore tarsi and constitutes the tarsal comb, which undoubtedly aids the females in digging their nests in the soil. The development of the spines of the tarsal comb varies with the different genera, as does the number of spines constituting it. In rare instances this structure is entirely lacking or is very weak and in the males it is at most rudimentary.

Upon the middle and hind metatarsi the two lateral rows of minute spines upon the ventral side are interspersed with spines of larger size, and there is usually an additional row of a few of the larger spines upon the anterior side of these segments. The remaining segments of the middle and hind tarsi bear only the median and two lateral, longitudinal rows, as already indicated, except for those at the apex. The armature of the tarsi of the males is uniformly weaker than that of the females of the same species.

Scopae, or areas of closely-set, short hair, are also present upon the tarsi, there being a longitudinal scopa upon the anterior side of each of the fore metatarsi and sometimes a faintly developed scopa at the apex of some of the other tarsal segments.

Situated at the apex of each of the first four segments of the tarsi, upon the ventral side, is a single minute, disk-shaped structure or cupule, which may possibly function as an adhesive organ, somewhat after the manner of the pulvillus.

The terminal segment of the tarsus is always fitted with a pair of well developed, sharply-pointed claws, each of which has upon its ventral side either a small, sharp median tooth or a longer process, which lies parallel to the outer portion of the claw itself, but is somewhat shorter and abruptly truncate at its extremity. Claws having this truncate process are said to be cleft, while those having the sharp, median tooth are called "toothed claws."

In the greater number of genera the possession of the cleft or toothed structure of the claws appears to be a sexual character and is constant for all species of any particular genus, the claws of the females usually being toothed and those of the males cleft. Various exceptions and modifications from this condition, however, occur. In the females of Batozonus and the males of Pycnopompilus the claws of the front tarsi are cleft, those of the middle and hind tarsi toothed.

In the genus Sophropompilus, the tarsal claws of both males and females are toothed, while in Spilopompilus and Allocyphonyx the claws in both sexes are cleft. The tooth or the truncate process of the claws is usually situated upon the middle of the ventral side, but the claws of the males of Psammochares? philadelphicus (Lep.) are peculiar in that the truncate process is slightly displaced toward the inside of the claw.

Another peculiar modification from the normal structure of the tarsal claw is to be found in the case of the anterior claw of either of the front pairs in the males of many genera (Lophopompilus, Allocyphonyx, Pycnopompilus, Arachnophroctonus, etc.) this claw being recurved at its apex and of a shape quite

distinct from that of the other claws. This modification does not occur in Batozonus and Poecilopompilus.

The pulvillus is a hoof-shaped structure, having a chitinous base and a fleshy extremity, which lies between the tarsal claws. Dorsally it is hollowed-out or cup-like and is overhung by a small chitinous piece, attached between the claws at their base, which bears numerous, fine curved bristles upon the apex. A few stiffer bristles arise from the base of each claw upon the ventral side and extend to near the apex.

Wings.- These structures are strongly developed, the fore wings being nearly or fully equal, as the case may be, to the length of the body, and the hind wings about three-fourths the length of the front pair. All the wings are covered with microscopic hairs, somewhat coarser at the base than apically. The veins are also well developed and furnish a strongly supporting structure.

The predominating color of the wings is blackish-fuscous. Hyaline, yellowish, brownish and rufous are also characteristic colors, but occur less commonly, and all wings, irrespective of color have a narrow apical margin darker than the rest of the wing. A violet or metallic reflection is often in evidence, this being more apparent upon deeply colored wings.

From a taxonomic standpoint it has seemed desirable to follow the system of nomenclature of the veins and cells used by Cresson and others.

Fore wings.- (Plate fig.) The costal vein lies upon the anterior margin of the wing and usually terminates at the apex of the marginal or radial cell, or at most is weak and indistinct beyond this point. The subcostal vein lies just inside the anterior margin and terminates at the small stigma,

which is located upon the anterior margin at the base of the marginal cell, about two-thirds the distance from the base to the apex of the wing. Between the costal and subcostal veins, and also terminating at the stigma, is the long, narrow costal cell, posterior to which, in order, are the median or externo-median cell, the submedian or interno-median cell and the anal cell. The first two are of about equal length and are separated by the median vein (externo-median of Dahlbom, Cresson et al..) the former being triangular in shape and the latter rectangular. The anal cell is somewhat longer than the median and submedian cells and extends about two-thirds the distance from the base of the wing to the apex upon the posterior margin, being bounded anteriorly by the anal vein and posteriorly by the margin of the wing itself. The basal and transverse median veins form the distal terminations of the median and submedian cells, respectively. The position of each of these veins with respect to the other, upon the median vein, varies considerably, in some cases being interstitial, that is, forming an even junction, or either one may originate before or beyond the other upon the median vein.

The marginal cell is pointed basally and apically, and varies from gently bowed to nearly angular, posteriorly, according to the outline of the marginal or radial vein. The cubital vein originates upon the basal vein, usually at a point slightly nearer the subcostal than the median vein, and extends nearly to the apex of the wing, forming the posterior limitation of the first, second and third submarginal or cubital cells. The shape of the first and second submarginal cells is much the same throughout the various genera, the first being a five-

sided trapezoid, but approximating a long narrow triangle in outline, and the second quadrate. In the case of the third submarginal cell, however, due to the difference in the position of the third transverse cubital vein upon the marginal vein, the shape of this cell may be extremely variable. For instance in Batozonus, Poecilopompilus, Arachnophroctonus, Spilopompilus, etc., the third submarginal cell is trapezoidal in shape, usually being but little narrowed upon the marginal vein. In Lophopompilus this cell varies in shape from subquadrate to subtriangular, sometimes being narrowed but little upon the marginal vein, while in other cases it is more strongly narrowed, or subtriangular, the second and third transverse cubital veins nearly meeting. In other instances these veins actually meet upon the marginal vein, making the third submarginal cell, distinctly triangular, or they may unite before reaching this vein and be joined to it by a short petiole, in which case this cell is said to be petiolate. In the wings of most specimens of Aporus fasciatus Sm., the second transverse cubital vein is lacking, there being but two submarginal cells. In comparatively few specimens of this same species this vein is present, and an occasional specimen shows only a trace of it. Whether this anomaly is a tendency towards the permanent loss of the second transverse cubital or what might seem to be a comparatively recent inclination towards its acquisition, it is not possible for the writer to state.

The first, second and third discoidal cells show little variation in the different genera, the first discoidal cell being roughly triangular in shape and the second and third rectangular or nearly so. The discoidal vein

originates at the junction of the median, transverse median and basal veins, extends for a short distance towards the apex and then curves rather abruptly towards the posterior margin of the wing, where it unites with the anal vein at the apex of the anal cell. The subdiscoidal vein originates upon the discoidal just anterior to the anal cell and extends to but little beyond the third discoidal cell, falling considerably short of reaching the apex of the wing. The junction of the subdiscoidal vein with the discoidal makes a characteristic dip or pocket in the third discoidal cell, peculiar, according to Banks, to the subfamily Psammocharinae.

The first recurrent vein runs forward and outward from its junction at the bow in the discoidal vein to the cubital, usually meeting the latter just before its union with the first transverse cubital. The second recurrent vein is a cross vein, which extends from near the extremity of the subdiscoidal vein to the cubital, meeting the latter at about the middle of the third submarginal cell.

Hind wings.- (Plate fig.) The veins of the hind wings are strong but are comparatively few in number. The costal vein lies upon the anterior margin, but is quite short, being strong basally but becoming weak and indistinct before reaching the stigmal region, which is located a little more than half way to the apex. The subcostal vein branches from the costal a short distance from its base and meets the anterior margin just beyond the stigmal region, extending along the margin from this point nearly to the apex of the wing, where it becomes indistinct and disappears. The frenal hooks are attached to the subcostal

vein where it meets the anterior margin. The marginal vein originates upon the subcostal in the stigmal region, extends posteriorly for a short distance, then curves abruptly outward and reaches nearly to the apical margin. The median cell is irregular in shape and shows little variation. The median and discoidal veins are united into one continuous vein, the exact limits of each being indefinite. The basal portion of this vein which extends to about the point where the cubital joins it, is designated the median, and the portion beyond this point the discoidal vein, which curves gently backward and extends nearly to the hinder margin of the wing. The anal and transverse median veins are also joined into one continuous vein, the basal portion being designated the anal, and the distal part the transverse median, the latter being the part which curves forward to the median. The point where it unites with the median may be arbitrarily assumed as marking the end of the median and the beginning of the discoidal. The cubital may arise from the end of the median, in which case it is interstitial with the transverse median, or a short distance basal to this arising from the median, or it may be external to the transverse median upon the discoidal. It extends forward for a short distance, then curves rather abruptly towards the apical margin, before reaching which it terminates indistinctly. It is joined to the marginal by a short cross vein, the transverse cubital. The basal lobe is well developed and may be rounded apically or somewhat pointed.

Abdomen

This region of the body is somewhat spindle-shaped and is approximately equal in length to the head and thorax

combined, its attachment to the latter being rather close and narrow, though not forming a true petiole. The segments are more or less telescoped, each segment being overlapped by the preceeding and the dorsal portion of each segment partly covering over the ventral part. The abdominal spiracles are not visible. As a matter of convenience the morphological second abdominal segment will be called the first in this paper.

Abdomen of female.- In this sex the abdomen consists of six segments, the second of which is the longest and usually has the greatest circumference. The abdomen expands abruptly from the point of attachment, the first segment being bell-shaped, somewhat flattened beneath, and tapers more gradually towards the apex, which is sharply pointed and sometimes compressed laterally. The ventral abdominal sclerites and the entire apical segment are sparsely furnished with hair-like bristles, those upon the apical segment being more numerous and stronger. The genital organs of the female seem to present no characters which are available for classification.

Abdomen of male.- This consists of seven segments. It is usually less expanded than that of the female, is often somewhat flattened dorsally and tapers rather evenly towards the base and extremity, the apex being less pointed than in the female and often truncate. The bristles found upon the terminal segment in the females are lacking in the males, and when present upon the ventral segments are comparatively weak.

There are a number of structures present upon the apical, ventral sclerites in this sex, which furnish excellent characters for the separation of genera, but are less frequently useful for the determination of species. The last ventral segment of the

abdomen, here termed the subgenital plate (plate fig.) exhibits an extremely varied structure in the different genera, and has been recognized as a character of importance by various writers upon this group. Schiödte refers to it as the "marium valvula analis" (1837) and Dahlbom designates it the "valvula analis ventralis" (1843). Taschenberg makes similar mention of it (1869). Radoszkowski designates it the "couvercle genital" (1887) and Lucas applies the term "Subgenitalplatte" (1895) to this same structure. Other writers have perhaps availed themselves of this character but many seem not to have recognized its importance.

Among some of the various shapes which the subgenital plate may assume the following are most commonly met with. It may be rounded, pointed, truncate or incised apically, and convexly rounded, flattened, and narrowly or broadly carinate ventrally. The apical margin is usually inconspicuously armed with small spines. The base is drawn out medially into a narrow process, which might roughly be said to bear about the same relation to the subgenital plate proper that the handle of a trowel bears to the trowel blade. This process is concealed by the preceeding ventral plate. Lying ventral to the basal portion of the subgenital plate proper, and also concealed by the penultimate ventral plate is a small sagittate plate which is destitute of vestiture and is attached to the subgenital plate by a delicate, chitinous membrane. This plate is separable from the latter only by rupturing this membrane. Radoszkowski has apparently designated this combined structure, i.e., the subgenital plate proper, the basal projection and the attached sagittate plate, the "couvercle génital" or genital cover,

and it will also here be considered as a single structure, the subgenital plate. The shape of this sagittate portion of the subgenital plate varies to some extent in the different genera.

The genus Lophopompilus is remarkable in that it differs from all other genera of the subfamily in the possession of what Radoszkowski has termed a "couvercle genital panache", a plumose genital cover or subgenital plate. Here the apex of the sagittate plate bears a plumose projection backward which is usually visible as a small tufted piece at the base of the subgenital plate proper, extending from underneath the emargination in the center of the penultimate sclerite. In this genus the subgenital plate proper is rounded apically and gently convex ventrally, differing in no way except perhaps its shape, from this structure in the majority of genera. The penultimate ventral sclerite is always emarginate posteriorly. Upon each side of this emargination is a small hook, here termed the emarginal hooks, which, according to Lucas correspond to rudimentary styli. This sclerite shows some variation in the different genera, particularly in the width and depth of the emargination.

Other structures occurring upon the ventral abdominal plates, and which have been made use of by Lucas (*Die Pompiliden - Gattung Pepsis*; 1895) may be termed ventral tufts. These consist of groups of long hairs, characteristically arranged, and usually present upon either the fourth or fifth segments and less frequently upon the third. These ventral tufts are well developed in the males of some species of the genus Aphiloctenus and are also present in other genera.

Another important ventral structure which occurs in the males of the species Psammochares ? philadelphicus (Lep.), P. turcius (Fabr.), etc., consists of a small lunate, velvet spot upon the posterior margin of the fourth segment. Taschenberg made mention of this in his description of Pompilus amethystinus. As to the function of this and other ventral structures there seem to be no data, but it is probable that they are related in some way to the genital system, that is, genital accessories.

Male genitalia.- (Plate fig.) The work of Radoszkowski ("Revision des Armures Copulatrices des Males de la Famille Pompilidae," Bull. Société des Naturalistes, Moscou, 1888. N. S., 2.) appears to be the most comprehensive treatise yet published upon this subject which deals with the group under consideration. Lucas ("Die Pompiliden - Gattung Pepsis," 1895) figures the genitalia of a large number of species of the genus Pepsis, which belongs to the closely related subfamily Pepsinae.

The genitalia consist of a chitinous sheath surrounding a fleshy body and are situated within the abdomen between the last dorsal and ventral sclerite, rarely being visible externally. These organs are easily removed by softening the specimen and then teasing them out with fine forceps or needles. Boiling is the quickest and safest method of softening when plenty of duplicate material is at hand. The most satisfactory mounts for study have been obtained by the following steps (1). Remove the genitalia and boil for a few minutes in 10 per cent potassium hydroxide. (2). Wash in water and run through 50, 75 and 95 per cent (commercial) alcohol. (3). Clear in oil of origanum. (4). Mount in balsam. While running the specimens through the alcohols, which should not require more than a few

minutes in each percentage used, it is desirable to flatten them out with small weights of some sort, a position which will be retained after mounting and will permit better opportunity for study. The fleshy material is dissolved by the potassium hydroxide, leaving the sheath unchanged and semi-transparent. The practice of mounting the genitalia upon cardboard and pinned along with the specimen from which these organs are removed is not only unsafe, but will not permit the close study often required for the separation of related species.

The genitalia consist of two main parts, a basal portion and an apical portion, which are easily separated by the rupture of a delicate connecting membrane. The basal portion, or cardo, is more or less cylindrical in shape and has a muscular attachment within the abdomen and a basal, hinge-like articulation upon its ventral side with the base of the subgenital plate. The cardo presents no character of importance for classification. The apical portion, or genital structure proper, is bilaterally symmetrical and consists of several distinct parts, which will be discussed in detail.

1. A median, more or less flattened piece, here termed the uncus (Plate fig.). Radoszkowski called this organ the "crochets." This structure shows considerable variation in some of the genera but differs little or not at all for species of the same genus. It is usually constricted at the base and expands more or less medially or distally, the apex being variously shaped and always medially incised. The lateral margins of the uncus are finely serrate or spinose and are frequently shallowly notched on each side of the apex, as in the genus Lophopompilus. Extending from the median

apical incision to the base of the uncus is a chitinous thickening, which marks the division of this organ into two symmetrical halves and forms a longitudinal groove termed the "fourreau" by Radoszkowski.

Situated upon the uncus and extending from near the apex to the base is a longitudinal canal giving off numerous tubules that appear to open upon the ventral surface of this organ. (Eyepiece 10 - objective 4m. m.). The surface pores or openings of these tubules are for the most part furnished with minute spines. It is probable from their nature that these function as glandular spines. The longitudinal canal usually extends laterally only about half way from the median line to the margin. Those pores which are located towards the middle appear to have no tubular attachment, opening directly from the canal upon the surface, while those which are located towards the margin usually extend outward from the canal for some distance beneath the surface before opening to the exterior. The arrangement of these tubules shows a marked similarity for species of the same genus and usually quite a different arrangement for those of distinct genera. No previous mention of these tubular structures has been found.

Situated at the base of the uncus upon the ventral side is the rather large, penial opening. The penis itself has not been observed, although a large number of unmounted as well as mounted genitalia have been examined, but it is said to be a "flexible and membraneous organ which is deeply retracted under the base of the uncus when not in use." The two sexes are rarely taken while in copulation so that the

function of the various genital organs of this group is unknown.

2. A pair of slender, rod-like organs, destitute of spines or hair, one lying on each side of the uncus and meeting basally on the median line dorsal to the uncus. (Plate fig.). These structures, here termed the sagittae, and "la base du forceps" of Radoszkowski, are of nearly uniform diameter for their entire length and show only minor differences in shape and in the relative length of these pieces to the other organs throughout the various genera. The sagittae are rarely sufficiently distinct in related species to be of value.

3. A pair of organs, broadened more or less apically, one lying outside of each sagitta, which are termed the volsellae. (Plate fig.). The ventral surface of these structures is always rather densely furnished with spines, some of which, at least, appear to be of the glandular type and have a tubular connection with the inside of these organs, but are much coarser than the spines upon the uncus. They are constricted basally and usually more or less enlarged from this point outward, but often curved inwardly and somewhat pointed at the apex. These organs, however, differ considerably in minor details of shape, armature, etc. in the different genera and to a greater or less extent in distinct species of the same genus, sometimes furnishing the most obvious characters presented by the genitalia for the separation of species.

At the base of each volsella upon the ventral side usually is a group of several long hairs and medial to these a small, stout hook, which is directed inward and may be unidentate (in addition to the point of the hook itself) as in the genus Batozonus, or without a tooth as in Lophopompilus. The tooth, when present, is situated near the base of the hook

upon the inside. In Psammochares ? philadelphicus (Lep.) these hooks are lacking. Radoszkowski has shown these structures in some of his plates and has mentioned them in the text but, as far as can be determined, has not named them. In view of their apparent importance and the necessity of having to make occasional reference to them, they will here be termed the basal hooks.

4. A pair of lateral organs, one lying outside of each volsella, here termed the claspers. ("Branch du forceps" of Radoszkowski.) (Plate fig.). These structures are usually long, broad or slender, flattened or more or less cylindrical and always adorned with rather long hair. The claspers often furnish the most distinctive characters presented by the genitalia for the separation of species, and show a wide range of structure in the various genera. A small scale-like or tooth-like projecting piece (Plate fig.) often occurs upon the ventral side or upon the outside of the clasper, usually near the base, as in the genus Lophopompilus, etc., but sometimes located higher up at about the middle, as in Psammochares ? philadelphicus Lep. etc. This projection will be termed the genital squama. In some genera the genital squama does not occur, as in Arachnophroctonus, Batozonus, etc.

Still another abdominal structure of some importance is the genital palpus. There are two of these short, densely-haired organs, one attached upon each side of a membraneous basal portion and lying just beneath the last dorsal abdominal sclerite. The membraneous basal portion is finely haired at its apex and appears to have an attachment with the subgenital

plate, this attachment being membranous and extending around each side of the cardo, so that these two structures, the genital palpi and the subgenital plate, are frequently removed together. The genital palpi show some variations of structure in the different genera but are usually not sufficiently distinctive to be of value.

